Title: Quantitative JPL Software Estimation Models for Cost, Size, and Defect Prediction
Topic: Cross-Cutting Themes
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Abstract:
Recently the Software Quality Improvement (SQI) Project has been formed to achieve and sustain excellence in software engineering at JPL to enable mission success. It will enable and promote software best practices, and leverage JPL experience in software engineering in support of major software projects, throughout the entire software life-cycle. The goal of the SQI Project is to establish an operational software improvement program that results in the continuous measurable improvement of software quality at JPL. Its objectives include improving cost and schedule predictability, improving the quality of mission-critical software, reducing software defect rates during testing and operations, increasing software development productivity, promoting software reuse, and reducing project start-up time. This presentation will focus on the results of SQI's Measurement and Benchmarking activities to develop quantitative cost, size, and defect estimation models based on the analysis of JPL data.

In support of the SQI project, we are validating and calibrating commercial parametric tools such as COCOMO, SEER-SEM and Price S as well as developing our own models. There is a major focus on developing a JPL version of the COQUALMO model to provide defect introduction and removal estimates as part of our cost estimation activities. As a result of integrating our cost databases and engaging in an extensive data collection activity over the next few years it has also become possible to analyze the historical datasets for trends in software development cost, productivity rates, as well as some schedule and quality-related metrics. In this paper we will summarize our activities as well as the software trends and their impact on the cost of developing flight and ground software.

The estimation model architecture describes the relationships between the various models that are under development. These models include: 1 Parametric SW cost models COCOMO II & SEER-SEM calibrated to the JPL environment for flight and ground software 2. JPL SW Defect Rate & Prediction models. 3. Effort decomposition tables that map the cost estimate into activities, lifecycle phases, and JPL's standard WBS 4. Experimental cost models for Fault Protection and MDS Software

The presentation will provide a brief overview of the SQI measurement program as well as describe each of these models and how they are currently being used in supporting JPL project, task and software managers to estimate and plan future software systems and subsystems.

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Quantitative Software Models for the Estimation of Cost, Size, and Defects

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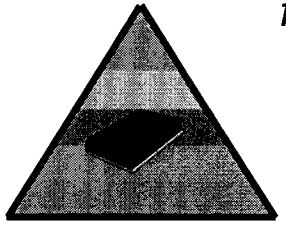
The JPL SQI Project

Process & Product Definition

Capture, define, and refine repeatable processes and a set of engineering practices for project use



Measurement & Benchmarking

Provide measurement infrastructure for projects, conduct empirical analysis, and package experiences for future use

SQI Project Engineering

Provide overall technical infrastructure and work element integration

Software Engineering Technology Infusion

Identify, evaluate, and support software tools and techniques to facilitate process and product improvement

Deployment

Infuse practices into project use; provide training, products, mentoring and consulting for projects

SQI Measurement & Benchmarking

The main objective of the SQI Measurement Program is to provide the basis for a quantitatively based software management approach

- Define models and measures
- Create an infrastructure
- Provide consulting and support
- Produce Handbooks & Training

Approach to Models & Measures

- Cost estimation and planning
  - Help develop total cost and schedule
  - Help plan internal project activities and phases
- Quality planning and assessment
  - Help predict and assess the quality of products
- Management tracking
  - Help managers plan and monitor detailed activities
  - Help managers assess risks during project execution
- Guiding improvement
  - Help JPL assess the overall effectiveness of software processes

Background

Existing Databases (190 data records)

- **1986 – 1989: NASA Software Cost Database and Model**
  - 100 Ground and 20 Flight data points at subsystem level collected after completion
- **1989 – 1993: SORCE/SSORCE Software Cost Database**
  - 49 data at points at assembly level, collected at time of delivery
- **1990 –1998: TMOD Software Cost Database**
  - Over 15 Upgrade Tasks with planned and actuals at assembly level
  - Contains breakdown by lifecycle phase and activity
- **2001-future: JPL wide Software Cost Database**

SW Model Architecture

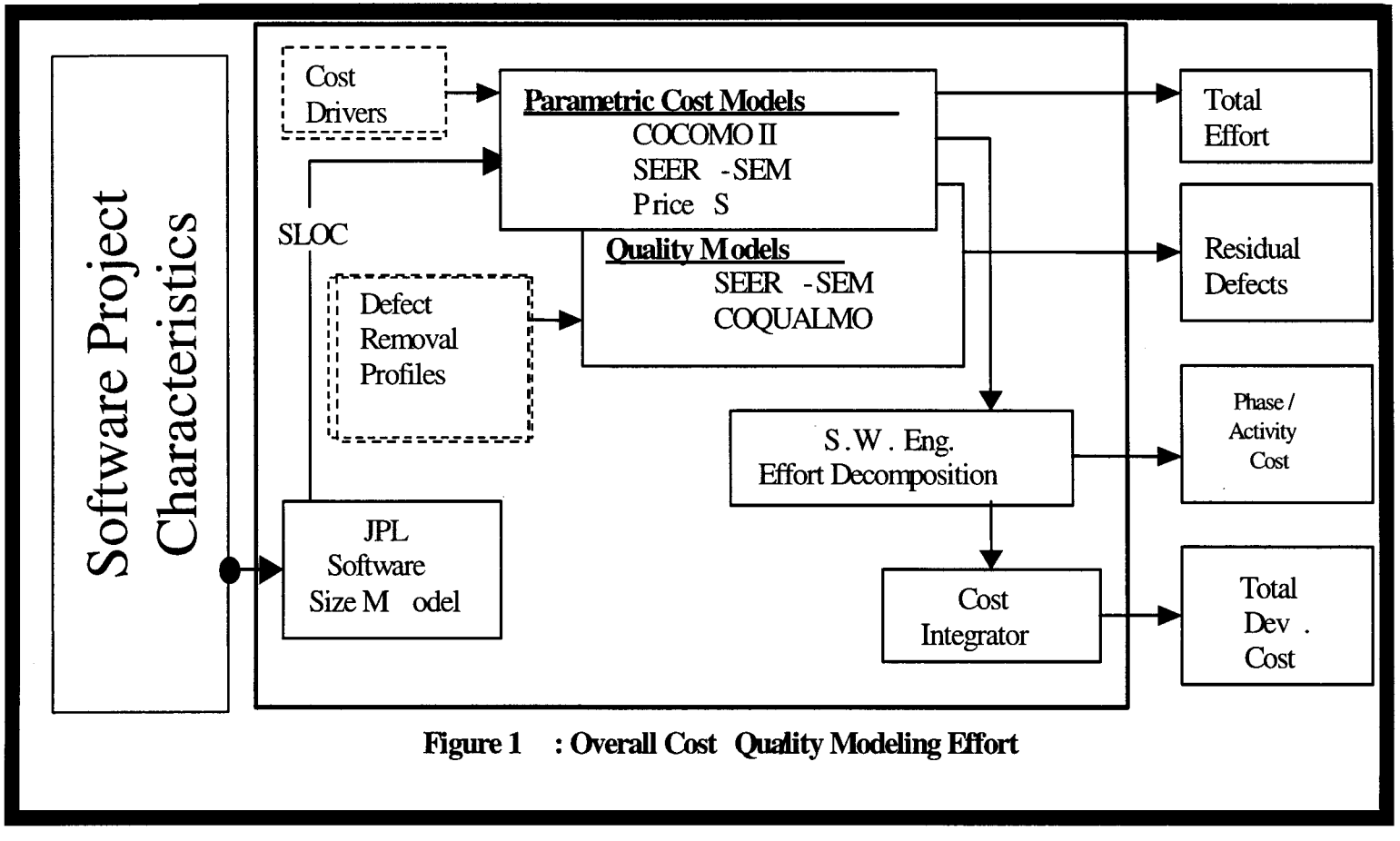
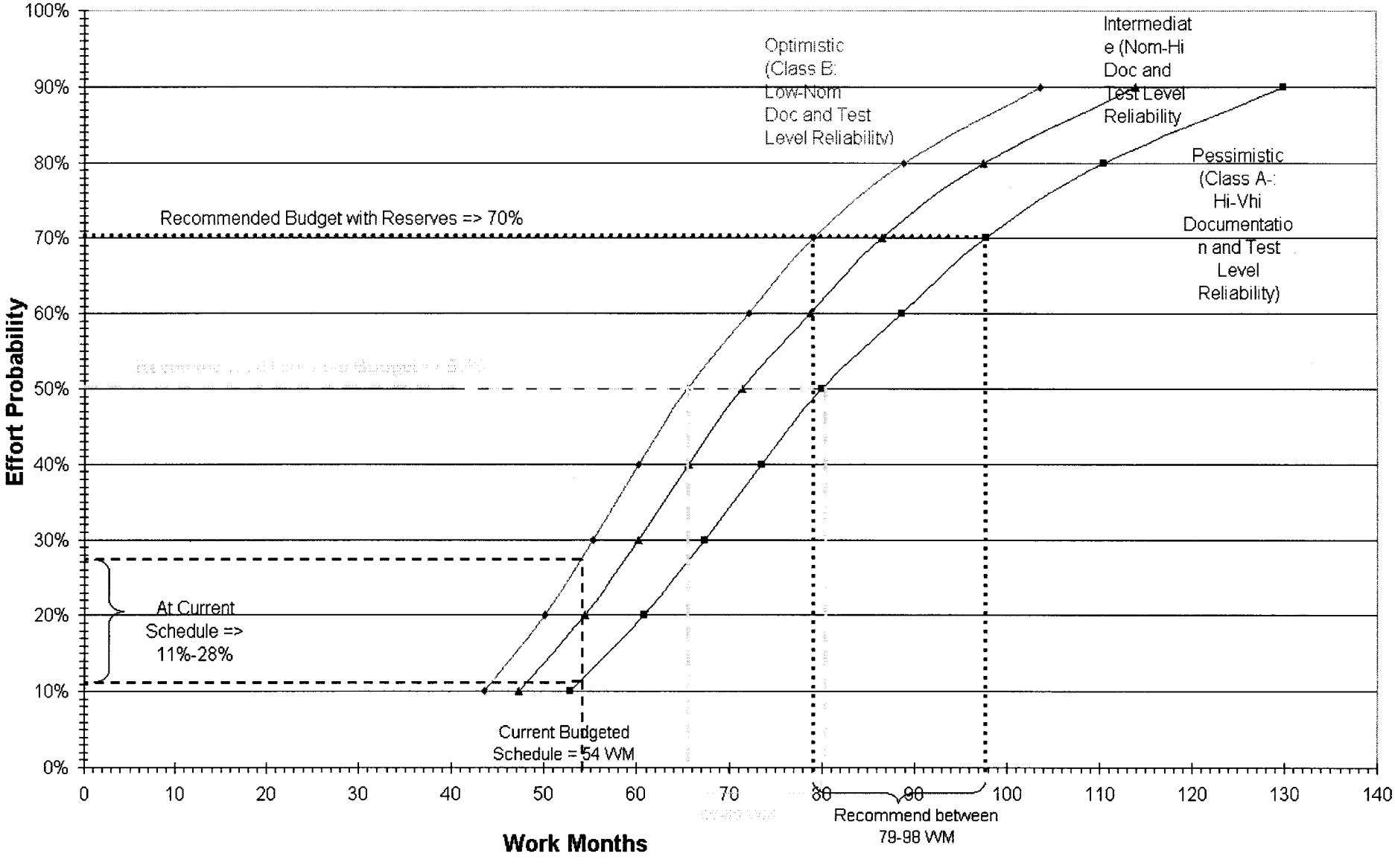


Figure 1 : Overall Cost Quality Modeling Effort

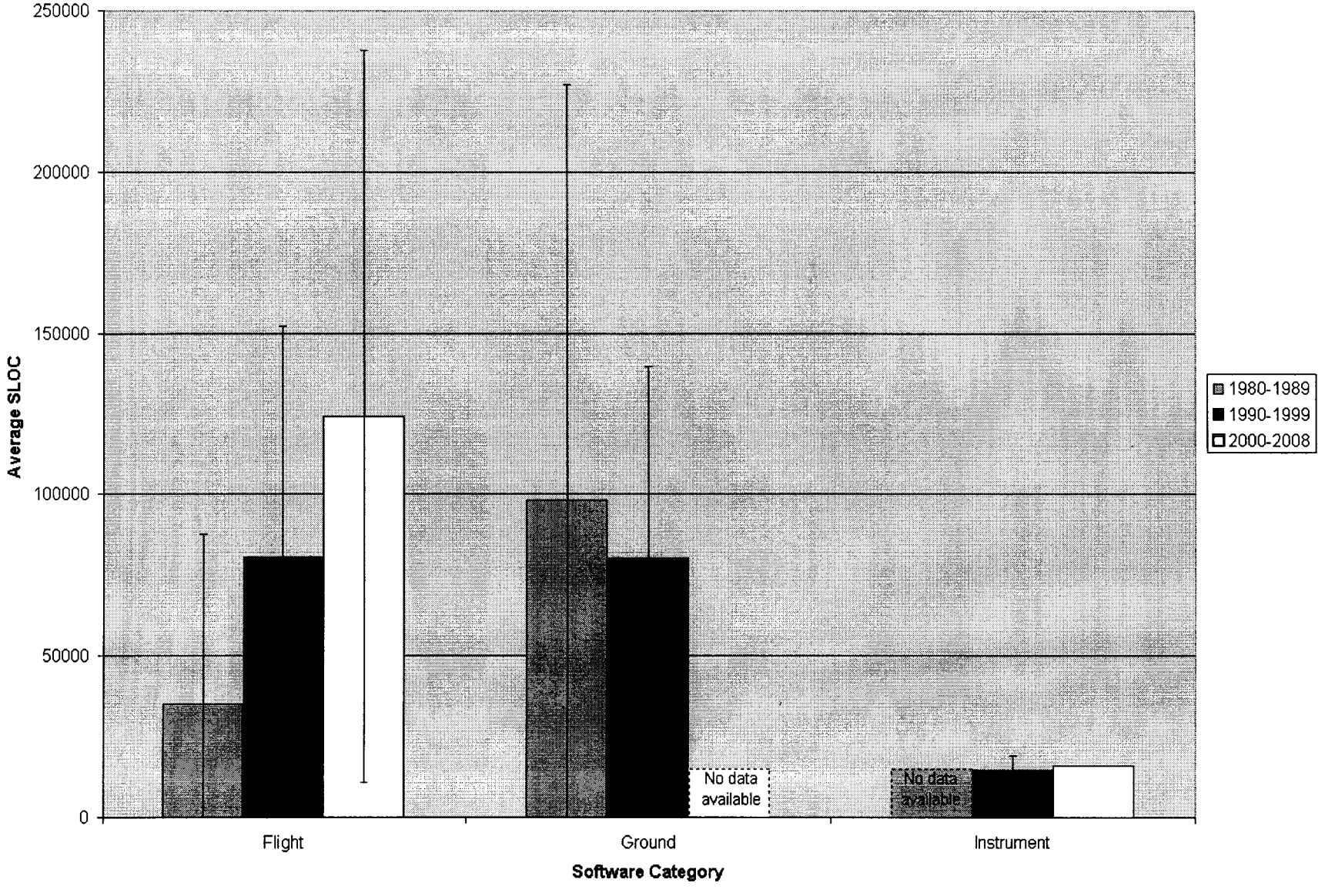
Model Validation

- **Evaluated COCOMO II (Post Architecture), SEER-SEM, and PRICE S "out of the box", i.e. without calibration**
  - On average >50% of projects predicted within 30% of actual
  - Flight software was better predicted than ground software
- **Also evaluated SEER-SEM using the knowledge base default settings only – no parameter inputs**
  - Did not predict well
  - Not recommended for the JPL environment
- **With more data, a calibration is expected to improve model performance further**

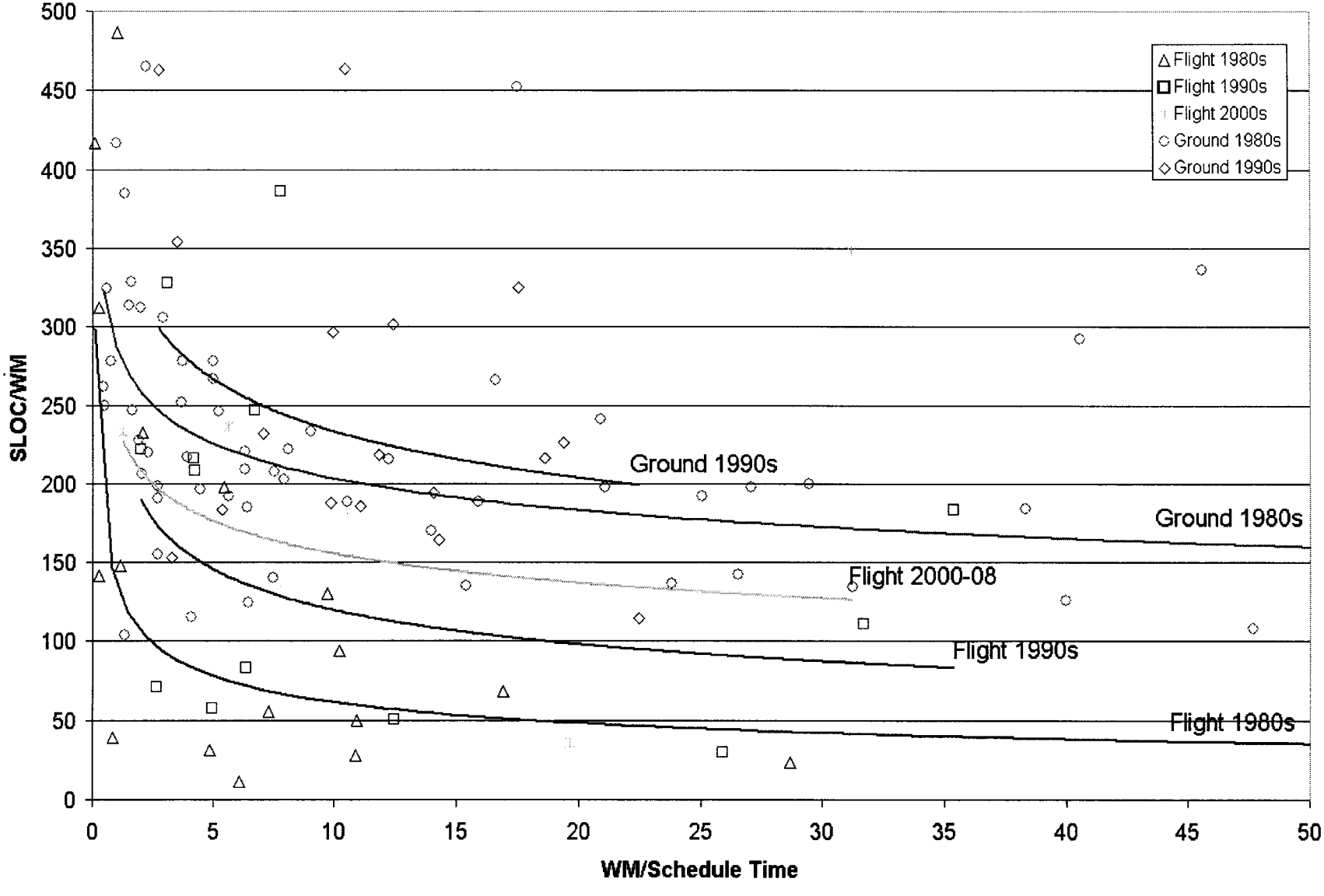
Actual Use of Cost Model Estimates



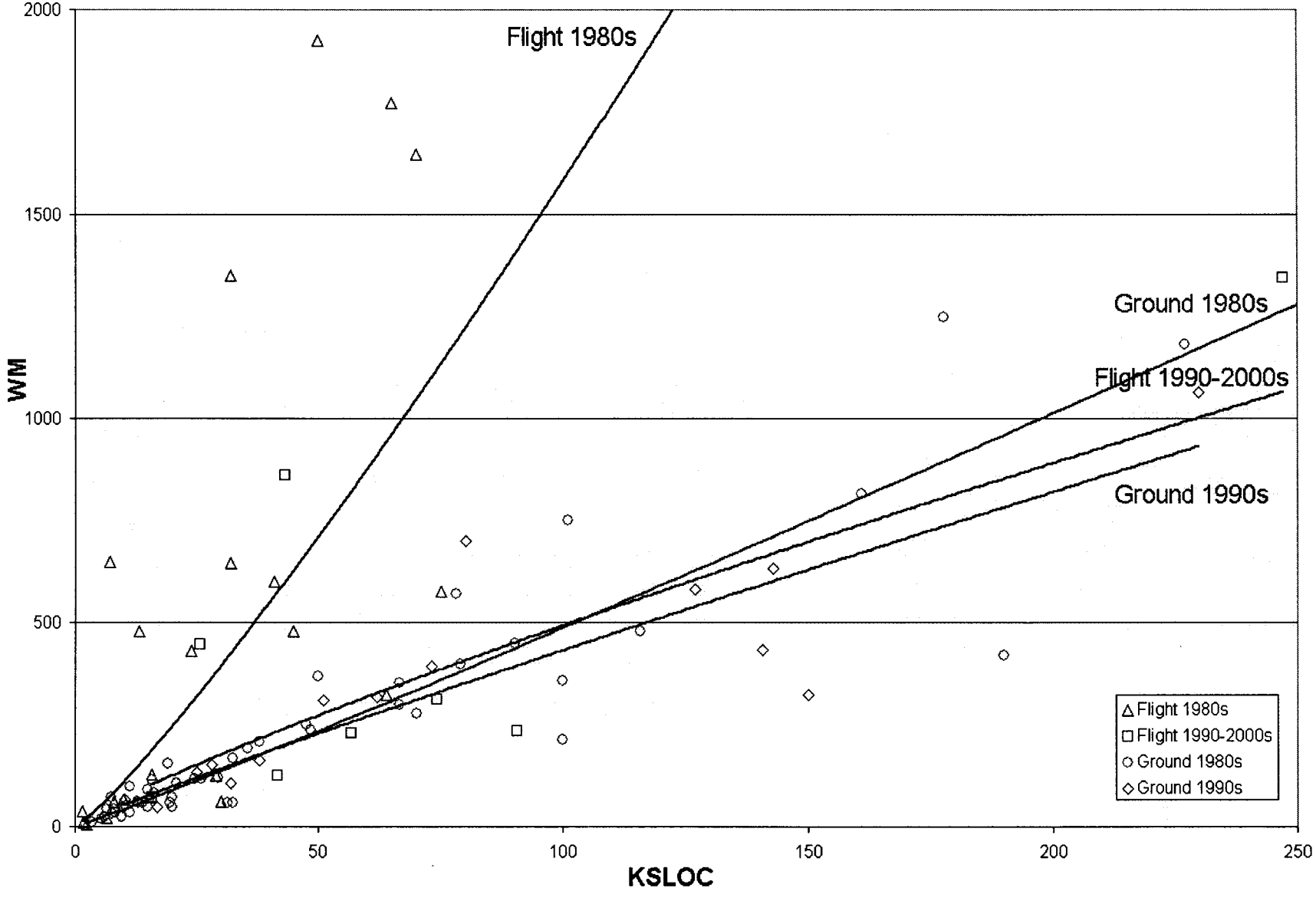
Average Software Size



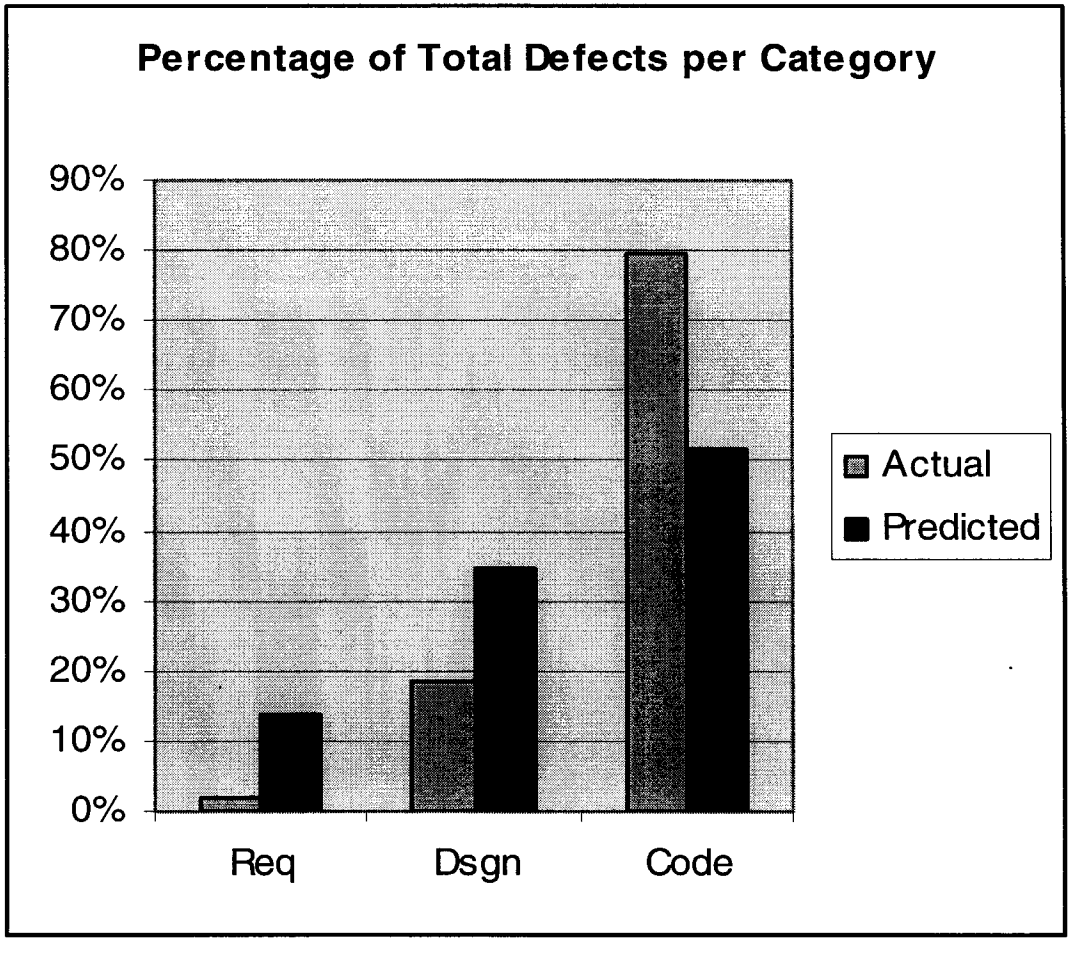
Productivity vs. Effort/Schedule



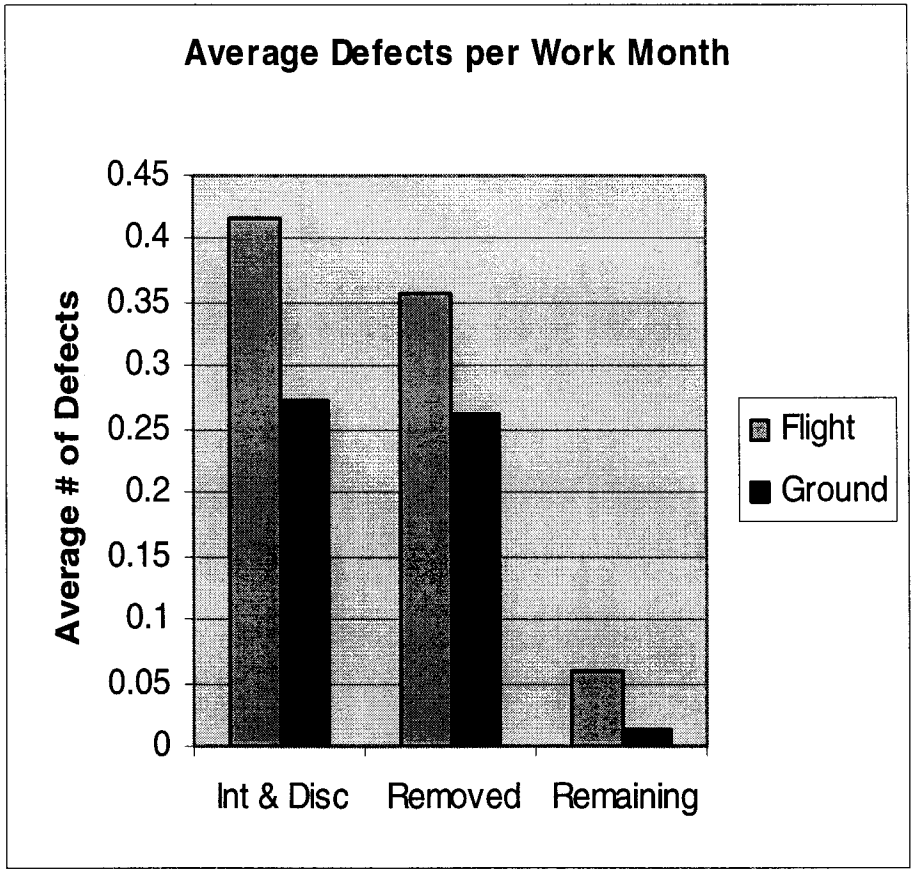
Effort vs. Size



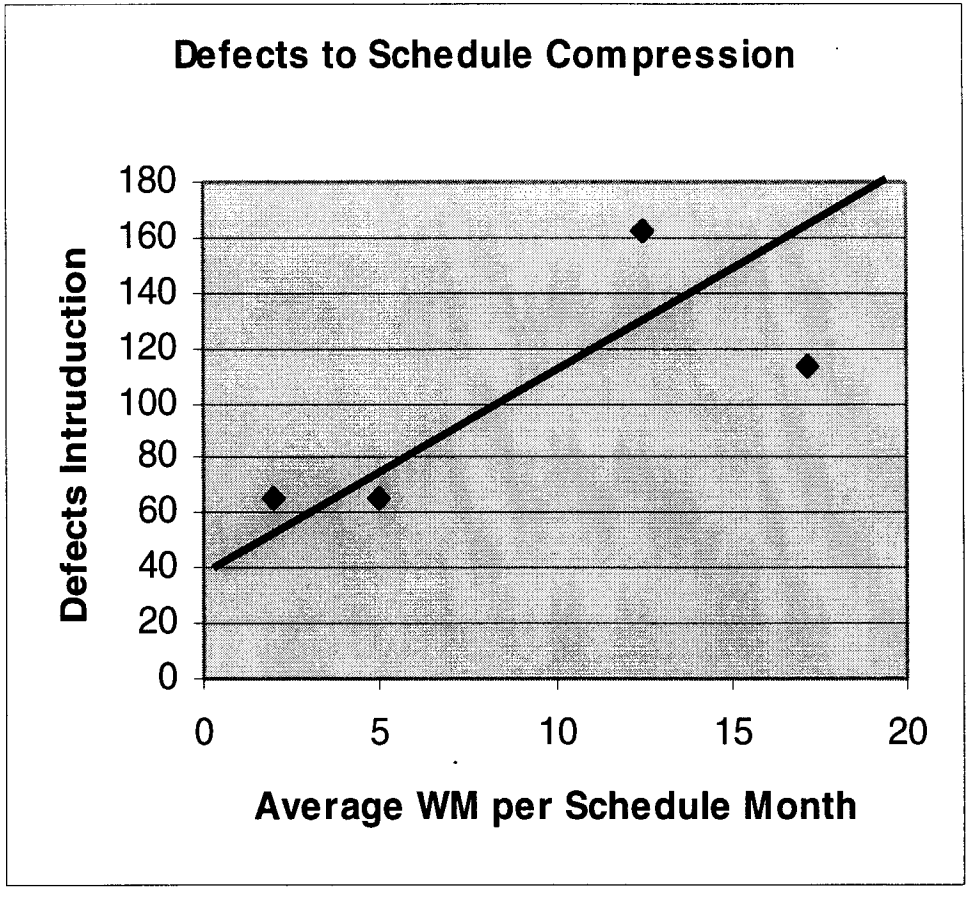
Defect Percentages by Category



Average Defects per Work Month



Defect by Work Months per Schedule Month



In Summary

The main objective of the SQI Measurement Program is to provide the basis for a quantitatively based software management approach

We are available to provide cost estimation and measurement support

Look on **http://software** for quarterly reports on baseline software engineering models you can use to help with

- Cost Estimation & Planning
- Quality Assessment & Planning